

## Do reduced tillage and non-inversion tillage techniques work on organic farms? Results from new European research

*There is widespread agreement across agriculture that reducing the intensity of tillage operations is a 'good thing'. But there are always 'pluses and minuses' and how far 'reduced tillage' can benefit or adversely impact organic farms has been a significant – at times contentious – question in recent years. Now the results of a three year, major EU study – 24 trials across 10 countries, case studies and farmer interviews – are providing some answers. Sally Westaway reports.*

**TILMAN-ORG**  
A European Network



In recent years research has shown that reduced tillage and the use of green manures can alleviate the problems created by repeated use of deep inversion tillage techniques such as mouldboard ploughing. Increased levels of soil organic matter, improved soil stability, increased soil biological activity and reduced fuel consumption have all been reported as benefits of reduced tillage<sup>1,2</sup>. However, the adoption of reduced tillage techniques in organic systems can present a challenge for effective weed control.

Through the Tilman-Org project researchers from the ORC have collaborated with European partners to investigate optimum techniques of applying reduced tillage and green manures to organic systems. The project aimed to:

- summarise existing knowledge and experience across a wide range of soils and climates;
- understand changes in soil quality and greenhouse gas emissions after reduced tillage and green manures in organic rotations;
- optimise weed management;
- increase nutrient use efficiency;
- design viable organic cropping systems applying reduced tillage and green manures for major European regions

ORC's role was to monitor an on-farm trial at Duchy Home Farm in South West England. Started in 2010, this trial compared conventional shallow mouldboard ploughing at 15cm with a reduced tillage system using an Ecodyn cultivator at 7.5cm.

### Key results from the Duchy trial:

- Crop cover after establishment was significantly higher for the reduced tillage plots in all three years. However this did not translate into higher yields and average grain yields were similar between tillage treatments for spring crops (spring oats and spring barley) but 50% lower for winter rye under reduced tillage.
- There was more weed cover after crop establishment under reduced tillage in all three cropping years, although later in growing season there was no difference in total weed cover or biomass between the two treatments.
- Shifts in the community composition of weeds were observed. In year 3 the density of grass weeds was greater under reduced tillage and in year 4 (the ley phase) weed species composition varied significantly between treatments with species such as *Sonchus asper* and *Taraxacum* agg. found in greater quantities in the reduced tillage plots and *Rumex* spp. and *Cirsium arvense* in the conventionally ploughed plots.

- Reduced tillage had a significant effect on soil physical properties, earthworm numbers and community composition. After three years there was an increase in the numbers of smaller earthworm species but the total biomass of earthworms was lower under reduced tillage compared to conventional ploughing. In year 3 the top 15cm of the soil was more compact with increased soil bulk density after Ecodyn cultivation. These differences between treatments in physical soil conditions and earthworm community composition were not seen under the grass/clover ley, indicating that the removal of cultivation allowed the soil and earthworm populations to recover.
- Fuel use was reduced by a third with reduced tillage and tillage operations could be completed in a quarter of the time compared to conventional ploughing.

The trial highlighted the need for more long-term monitoring of changes to weed communities and soil conditions under reduced tillage and for the development of machinery appropriate for differing farming situations.

### Key results from the whole Tilman-Org project:

A survey of 159 farmers interviewed across the 10 participating countries found that the main farmer motivations for switching to reduced tillage techniques are improved soil conservation and reduced energy input. The key reservations noted included concerns around effective weed control and the potential of increased labour<sup>3</sup>. No-tillage and reduced tillage practices were more popular amongst farmers in Mediterranean countries; whilst green manures are more often grown in wetter temperate regions.



*The adapted Ecodyn at Duchy Home Farm*



## Farmer Case Study: David Wilson, Farm Manager, Duchy Home Farm, Gloucestershire, UK



David has trialled the Ecodyn cultivator, a Non Inversion Tillage (NVT) machine developed by an organic farmer in Germany. The machine was used for 3 out of 4 years in the arable phase of a 7 year rotation. The fields were monitored during both the arable phase and the grass/clover ley which followed. The Ecodyn is designed as a one pass machine combining a cultivator and a drill. To suit the farm and soil type, the Ecodyn was modified by adding levelling tines on the outside of the machine and changing the seed feed tubes from plastic to stainless steel.

David found that use of the Ecodyn decreased fuel use significantly and improved efficiency in terms of the timing of operations. It led

to 'very good germination in dry conditions with rapid crop establishment in a dry spring'. However 'it doesn't work well in wet conditions and needs dry, free flowing soil, a plough is better to lift and aerate water damaged soils'. The crumbler roller became blocked quickly in any sort of damp conditions and David removed it completely. The machine's supporting legs, designed for deep loamy non-stony soils, kept bending in the stony soil and had to be replaced multiple times.

Nonetheless, David plans to persevere with the Ecodyn using it to tear up the turf on a 3 year ley on a compacted heavy clay soil. He has changed the machine set up to use narrow points for this. David would like to see a UK machinery manufacturer take the concept and produce a machine more appropriate for UK soils.

A meta-analysis of existing literature encompassing 58 studies showed that, across all regions, yields under reduced tillage were, on average, reduced by approximately 7% compared to conventional ploughing. However, in subtropical and dry Mediterranean climates reduced tillage techniques resulted in c. 10% increase in yields<sup>4</sup>. A difference in yield response between soil types was found with yield increases under reduced tillage seen on clay soils and yield reductions on sandy soils. Weed pressure and yields showed only a weak correlation. Conversion to shallow inversion tillage from deep inversion appeared to have many benefits (for example, increasing soil carbon) with minimal changes in yields; this response was applicable across a wide range of soil types.

The 24 Tilman-Org field trials across Europe showed considerable variability in yields between trials but, on average, reduced tillage methods led to an 8% yield reduction. Results of soil analysis indicate that this may be due, in part, to lower available mineral nitrogen in spring under reduced tillage. The use of green manures increased yields by an average of 8% depending on the crop, with 28%

more mineral nitrogen available in spring, suggesting that the application of green manures alongside reduced tillage could mitigate yield losses from reduced tillage alone.

Of the project field trials 40% showed higher weed abundance in reduced tillage compared to conventional ploughing. Weed community composition was influenced by tillage; 14 studies looked at weed communities and more than half showed a clear effect of tillage on weed community composition, with more perennial and volunteer species under reduced tillage and weed biodiversity often higher. A model to assess the functional traits of weed communities has been developed. Initial results from this model suggest that overall the weed communities found in conventional ploughing are taller, flower later and perennials are less abundant compared to reduced tillage. These differences were more pronounced in long-term trials.

Tilman-Org field trial results also indicate that soil carbon stocks are more stratified in reduced tillage compared to conventional ploughing and increase in the top soil. A subset of trial sites were selected for more in-depth analysis. A crop and site specific microbial (bacteria and fungi) reaction to different tillage treatments was also noted. N<sub>2</sub>O emissions also tended to be higher in reduced tillage, depending on farm management and the previous crop.

Overall results from the Tilman-Org Project suggest that in most cases crop yields under reduced tillage tend to be reduced but not substantially. The use of green manures can mitigate this. Further development is needed to develop farm specific reduced tillage systems through optimised timing of nutrient supply and improved, more adaptable, machinery.

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### References and resources

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2. Krauss M, Berner A, Burger D, Wiemken A, Niggli U, Mäder P (2010). Reduced tillage in temperate organic farming: implications for crop management and forage production. *Soil Use and Management* 26 (1):12-20
3. Casagrande M, Peigné J (2013) Conservation Agriculture in Organic Farming Motivations of European Farmers and Diversity of Practices. Paper at: Organic Producers' Conference, Birmingham, UK, January 22-23
4. Cooper J, Baranski M, Nobel de Lange M, Gattinger A. & Mäder P (2013) Using reduced tillage and green manures in organic systems – what is the research telling us? Paper at: Organic Producers' Conference, Birmingham, UK, January 22-23.
5. Tilman-Org has produced several practice-oriented videos which can be found here <http://www.tilman-org.net/to-videos.html>. All project publications can be found here <http://orgprints.org/view/projects/TILMAN-ORG.html>